Improving Warfighter Capabilities . . .

MISSION PLANNING AND REHEARSAL TOOLS FOR THE LEGACY, INTERIM, AND OBJECTIVE FORCES

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Introduction

"The winner of an engagement will usually be decided by the soldier or aircrew that gains surprise, acquires the target, and accurately fires the fastest." This quote from Field Manual (FM) 1-112, *Attack Helicopter Operations* (U.S. Army 1997), unequivocally expresses the importance of "visual acuity" on the battlefield and shows Army aviation's foresight into what has evolved into two key enablers of the Objective Force: information dominance and situational awareness.

At the tactical level, Army warfighters in such systems as the AH-64 Apache Helicopter, the M1-Abrams tank, and the M2/M3 Bradley Fighting Vehicle visualize the battlefield most often through thermal sensors. Soldiers use Forward Looking Infrared (FLIR) sensors to navigate, to orient on engagement areas, and to acquire and identify targets prior to ordnance release. Yet, at the tactical level, the Army does not have a fielded system capable of predicting FLIR performance or even the capability of providing predictive FLIR imagery of the battlespace. Warfighters using FLIR systems must rely on their own visual interpretation of the battlespace based on two-dimensional topographic maps and low-resolution visual animations.

Weather conditions and target-terrain relationships significantly enhance or degrade FLIR sensor performance. Degraded FLIR images make navigation, target detection, and target identification more difficult to the warfighter who must visually acquire and identify enemy threats. Generally, weapons-effective ranges exceed the warfighter's ability to visually identify vehicular threats in FLIR. The inability to predict FLIR sensor performance (because of weather, line-of-sight considerations, and target-to-background terrain relationships) further compounds the problem. This situation increases time required to detect and identify targets, increases exposure time, and often decreases the advantages of standoff. Achieving situational awareness in FLIR is a most challenging endeavor.
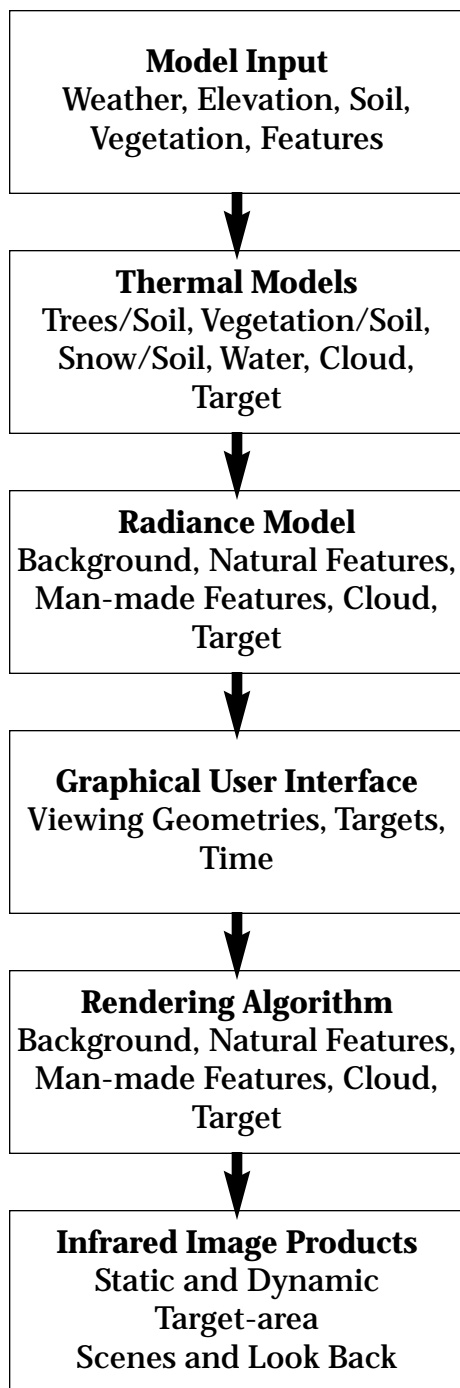
Concept Experimentation

The Concept Experimentation Program (CEP) is a separately funded program that provides the Army Training and Doctrine Command Battle Laboratories the ability to evaluate and capitalize on emerging technology, materiel initiatives, and warfighting concepts. The CEP facilitates experimentation to determine the military use or potential of a concept to become a Doctrine, Training, Leader Development, Organization, Materiel and Soldiers solution to the future operational capabilities. Normally a 1-year program, the CEP process consists of one submission cycle that is augmented by a quick-reaction identification and execution capability. The CEP is an effective and efficient method by which the research and development community can quickly determine value added to warfighter capability.

An Army science and technology objective entitled 3D Dynamic Multi-spectral Synthetic Scene Visualization began in FY99 to provide DOD with 3-D visualization tools for battlefield terrain and environmental information as they apply to infrared (IR) and millimeter wave sensor performance. In a collaborative effort, researchers at the U.S. Army Engineer Research and Development Center (ERDC) and Defense contractors supporting the Air Force Research Laboratory (AFRL) have produced the first-ever capability to provide warfighters in tactical or training settings with predicted FLIR scenes. This capability provides FLIR users with predicted, physics-based IR scenes prior to mission execution. The system operates using a client-server architecture, standard Internet browser, and soldier-oriented graphical user interface. The system ingests forecasted weather data, terrain, and target data to produce static and animated predicted IR scenes that replicate the parameters (fields of view, magnification, resolution, etc.) of user-specified FLIR sensors of choice (Figure 1). Capabilities also include a "look-back" feature that presents friendly vehicle IR signatures from the enemy's FLIR perspective.

Army Aviation Applications

Recognizing this as a challenge and a remarkable opportunity for Army attack aviation and future applications to the Objective Force, the Air Maneuver Battle Laboratory and the Aviation Directorate of Combat Developments at Fort Rucker, AL, sponsored a CEP experiment in predictive FLIR tech-

Model Input
Weather, Elevation, Soil,
Vegetation, Features

↓

Thermal Models
Trees/Soil, Vegetation/Soil,
Snow/Soil, Water, Cloud,
Target

↓

Radiance Model
Background, Natural Features,
Man-made Features, Cloud,
Target

↓

Graphical User Interface
Viewing Geometries, Targets,
Time

↓

Rendering Algorithm
Background, Natural Features,
Man-made Features, Cloud,
Target

↓

Infrared Image Products
Static and Dynamic
Target-area
Scenes and Look Back

Figure 1.
Flowchart of the process to predict IR scenes

nologies. The purpose of the experiment was to determine the military use and benefit that physics-based, predicted IR scenes of the battlespace would have on Army attack pilot performance. Specifically, the CEP would explore and document whether measure of performance improvements were realized in the areas of battle position selection and target detection.

CEP Experiment

The experiment was conducted July 9-13, 2001, at Fort Hood, TX, and was administered by the Aviation Test Directorate, U.S. Army Operational Test Command. The purpose was to quantitatively measure the performance improvement that predicted FLIR scenes would have on attack helicopter operations. Specifically, the experiment measured whether predicted scenes

improved mission planning (the pilots' ability to evaluate, rank order, and select the best battle positions) and mission rehearsal (resulting in faster and more accurate target detection during mission execution).

Thirty AH-64 Apache pilots were cross-leveled (by flight experience) and placed into two groups: the baseline group and the enhanced group. All company-level officers were represented (WO1 through captain). Both groups were tested on the same mission profiles and presented with mission planning and rehearsal tools used in attack aviation today (operations order, topographic map, operational overlay, Aviation Mission Planning System (AMPS), and line-of-sight application). In addition, the enhanced group was presented with static and dynamic predicted thermal views from each

To Determine Battle Position: NORMA

N—*Nature of target* (i.e., moving/stationary—seek flank or rear of enemy)

O—*Obstacle clearance* (i.e., height of terrain, vegetation, man-made obstacles in battle position)

R—*Range to target* (i.e., seek standoff greater than 2 kilometers)

M—*Multiple firing positions* (i.e., battle position should allow multiple firing positions per aircraft)

A—*Adequate area* for proper dispersion between aircraft

To Determine Firing Positions: BRASSCRAF

B—*Background:* aircraft should blend in with background

R—*Range to target:* seek firing position greater than 2 kilometers

A—*Altitude:* altitude of firing position is same or higher than engagement area

S—*Sun:* place sun at back of aircraft

S—*Shadows:* shadows should envelop aircraft

C—*Cover and concealment:* protection from direct fire and observation

R—*Rotor wash:* minimize and conceal rotor wash

A—*Adequate maneuver area:* battle positions should allow multiple firing positions per aircraft

F—*Fields of fire:* target must be visible for acquisition and tracking

Figure 2.
Aviation planning criteria

battle position to the engagement areas at the exact time the mission was to occur (notionally 24 hours in advance).

The experiment was conducted in a classroom environment. Enhanced group pilots received no formal training on how to use or interpret the predicted scenes. Actual AH-64 FLIR Target Acquisition and Designation Sight video was obtained through scripted Apache helicopter HELLFIRE missile engagements on a single target vehicle over complex Fort Hood terrain.

All 30 pilots were tested on their ability to properly rank order 10 potential battle positions in 2 separate engagement areas. CW5 Stephen Mitchell, an Army Standardization Instructor Pilot (SIP), determined the correct rank order based on aviation doctrine and a myriad of operational and tactical aviation planning criteria (NORMA/BRASSCRAF (Figure 2) and Mission, Enemy, Terrain, Troops and Time Available). The measure of performance was the rank order correlation of each group compared to the SIP. To test predictive FLIR scene effects on target detection, pilots were tasked to detect enemy vehicles in eight target detection vignettes (using multiple engagement areas and varying terrain, distances, and environmental conditions). Measures of performance were target detection time (seconds), number of false detections (detecting an object other than the target), and nondetections (failure to acquire the target). The CEP concluded with a written questionnaire.

Experiment Results

Predicted FLIR scenes improved pilot performance in all areas tested. Battle position selection was improved. The enhanced pilot group had a 75 percent agreement with the SIP rankings, statistically much more correlated than the control group. In the area of target detection, enhanced group pilots realized a substantial improvement in their ability to consistently detect targets, with 41 percent fewer false detections. Specifically, pilots exposed to the pre-mission visualization products improved target acquisition by 61 percent and target detection by 41 percent. Additionally, pilots in the enhanced group decreased their time required to detect a target by 6.5 per-

cent on average, with the highest decrease in a single engagement of 32 percent (a 19-second reduction). Interestingly, the engagement with the largest time improvement presented the most challenging terrain and adverse FLIR conditions.

Further, enhanced group pilots showed an 8 percent improvement on the engagement area with the farthest standoff range (approximately 3.7 kilometers). In this engagement, the enhanced group had 11 fewer false detections and 6 fewer nondetections than did the baseline group.

Finally, predicted IR technology received positive reviews, with 100 percent of the pilots surveyed stating that Infrared Target Scene Simulation Software (IRTSS) improved mission planning; 96 percent stating that IRTSS improved the intelligence preparation of the battlefield process; and 93 percent reporting improvements in confidence, situational awareness, and risk mitigation.

Future Applications

Predicted FLIR technologies support the goals and objectives of the Army's Objective Force by enabling information dominance and improved situational awareness. Specifically, this technology provides warfighters with an immediate understanding of environmental and atmospheric effects on FLIR sensors for direct application in the mission planning and rehearsal processes. Moreover, predicted FLIR allows warfighters, at the collective-individual levels, the capability to preview, in 3-D, FLIR scenes of the battlespace. Three-dimensional terrestrial views in the thermal spectrum enable warfighters and mission planners to evaluate and select the optimum location and time on target as they directly relate to terrain, weather, and target arrays. The capability is the first to combine high-resolution terrain data, vegetation effects, terrestrial line-of-sight applications, and target geometries in the IR spectrum into a medium that can be digitally rendered and delivered to the warfighter via a standard browser. By taking vegetation into consideration, delivery software greatly enhances mission planning and rehearsal products under development such as the Joint

Mission Planning System and the AMPS.

Overall, predicted FLIR scene technology demonstrates significant military worth and usefulness to the aviation warfighter, improving mission planning, rehearsals, and mission execution. ERDC and AFRL researchers contend that this technology can be applied to Legacy, Interim, and Objective Force combat vehicles and serve as a key enabler to the tactical capability of joint collaborative mission planning and rehearsal within a digital (onboard) environment.

Conclusion

The CEP process has proven an efficient, timely, and cost-effective method to debut and quantify the military use and operational and tactical benefits of predicted FLIR scene technology. If the decision is made for predicted FLIR capabilities to enter the formal materiel acquisition process, the technology is mature enough now to enter the life cycle at the system development and demonstration phase, thereby significantly reducing the time required for fielding.

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